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Energy Reports 8 (2022) 312–318

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The 8th International Conference on Energy and Environment Research ICEER 2021, 13–17 September

## Energy transition in Saudi Arabia: Giant leap or necessary adjustment for a large carbon economy?

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Received 28 December 2021; accepted 6 January 2022

Available online 2 February 2022

### Abstract

Since 2016 and guided by the National Vision 2030, the energy transition in Saudi Arabia has gained significant momentum. There have been important energy subsidy reforms and dynamic developments in the renewable energy sector. This paper provides a systematic view of the Saudi energy transition by highlighting drivers, sectors, targets and processes. It analyzes the progress with regard to lowering carbon emissions and consumption, as well as introducing ambitious new targets and solar energy projects. The energy subsidy reforms have delivered the needed funds for the energy transition and allowed for more participation in the energy markets. Other aspects of the energy transition included low-carbon urban developments and energy efficiency measures in the building sectors. Besides, key energy-intensive industries such as petrochemicals and desalination are incorporating renewables and facilitating the use of clean energy. Overall, the Saudi energy transition is underway, and it holds significant and necessary adjustments to the most important economy in the Middle East region. It needs to be complemented by environmental awareness and sustainable lifestyles. Reforming the large carbon economy of Saudi Arabia towards more sustainability and environmental responsibility can have positive spillovers and powerful messages about the future of carbon-fuel exporting states.

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Peer-review under responsibility of the scientific committee of the 8th International Conference on Energy and Environment Research, ICEER 2021.

**Keywords:** Energy transition; Energy subsidies; Renewable energy; Saudi Arabia; Low-carbon economy; Energy policy; Carbon footprint

### 1. Introduction

The Kingdom of Saudi Arabia (KSA) is an oil-rich country and the biggest economy in the Middle East, making it an interesting case of the energy transition in large carbon economies. It holds the second highest proven oil reserves worldwide. Besides, it has the highest production of oil (ca. 12 million barrels per day in 2017), and the third highest natural gas production (ca. 111 billion cubic meters per year in 2017) in the region of Middle East and North Africa (MENA) [1]. For decades, Saudi Arabia has been known for obstructing climate change agreements, and for dominating the positions of the oil-exporting countries which feared the negative spillovers of the energy transition

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on their carbon industries [2]. As the case of other countries of the Gulf Cooperation Council (GCC), there is lately an increased attention to renewable energies, energy subsidy reforms and the issue of sustainable development in general [3]. Guided by 2016 established National Vision 2030, Saudi Arabia has introduced bold reforms in order to introduce renewables, lower energy consumption and decrease the energy intensity of the economy [4]. Considering the Saudi influence and economic power, the consequences of the ongoing energy transition are quite significant for the MENA region in terms of reforming current fossil-fuel intensive economies. Therefore, studying the Saudi case enriches the energy transition literature in terms of motivation, instrument and repercussions of such transitions in large carbon economies. While academic literature on the Saudi energy transition is emerging, it often focuses on reviewing the progress and targets with regard to renewable energy [5,6]. Such targets have been changing rapidly due to the dynamic nature of the ongoing restructuring of the Saudi energy sectors. Therefore, there is a need for more comprehensive reviews of the energy transition in Saudi Arabia in order to understand the enablers, process, and sustainability of this transition. Using secondary literature and data from recent projects, the paper reviews the Saudi energy transition case by analyzing the drivers, instruments and involved sectors. It also contextualizes the Saudi case within the GCC and MENA regions and discusses potential implications.

## 2. The energy dilemma and drivers of transition in Saudi Arabia

There are generally two categories of explanations for the energy transition in Saudi Arabia. First, Saudi Arabia is facing an economic energy dilemma due to the declining prices and demands for oil globally, and the increasing domestic energy demands. In academic literature, this dilemma is presented as the main driver behind the energy transition in Saudi Arabia and the region. For example, Tagliapietra [1] sees the 2014 oil drop as a reason behind the adoption of ambitious plans for economic diversifications in the MENA region. Zaidan et al. [7] regard the national visions in GCC countries as a vehicle for economic diversification, while sustainability objectives are being aligned to these visions. Fattouh et al. [8] see no trade-off of renewables development in oil-exporting countries since renewable energy can liberate fossil fuels for exports and satisfy domestic energy needs. In Saudi Arabia, if alternative energies are not developed, the rapid increase of domestic energy demands can deplete almost all fossil fuels designated for export by 2030 [9]. In the Saudi National Vision, it is stated that the “local energy consumption will increase three fold by 2030” [10]. **Table 1** provides an overview of the clean energy aspirations as per the Saudi National Vision 2030 and their implementation so far.

**Table 1.** Clean energy aspirations in the Saudi National Vision 2030.

Aspiration	Formulations in the vision document (page Nr.)	Implementation (stand 2021)
Localization of renewables	“Localize a significant portion of the renewable energy value chain in the Saudi economy” (P. 49)	Evidence of localization progress so far provided in AlOtaibi et al. [6]
Renewables capacity	“Initial target of generating 9.5 gigawatts of renewable energy (P. 49)	Target raised in 2021 to 50% of capacity by 2030
Renewable investments	“Launch the King Salman Renewable Energy Initiative” (P. 49)	Initiative used since 2016 as a banner for renewables projects
Renewable energy sector regulation and participation	“Review the legal and regulatory framework that allows the private sector to buy and invest in the renewable energy sector” and “encourage public-private partnerships” (P. 49)	Renewables projects being realized by the domestic company ACWA power (single buyer) through purchase agreements (PPAs) with consortia involving private sector
Energy liberalization	“Guarantee the competitiveness of renewable energy through the gradual liberalization of the fuels market” (P. 49); “free market prices shall, in the long term, stimulate productivity and competitiveness among utility companies and open the door to investment and diversification of the energy mix in the Kingdom. We will also seek to set clear subsidy criteria” (P. 51)	Energy subsidy reforms introduced in 2016 and a Citizen Account Program established to provide more targeted support to eligible citizens

Second, there are several geopolitical and non-economic factors attached to the energy transition in the GCC region. Al-Saidi [11] explains the extrinsic values of sustainable energy in the region, and provides non-economic justifications such as prestige and modernity images attached to the development of large-scale renewable energy projects and the nuclear power. In fact, nuclear energy has been incorporated as a part of the future energy mix policies in the United Arab Emirates and Saudi Arabia. However, nuclear energy is not mentioned in the Saudi

National Vision. Al-Saidi and Haghrian [12] explain the nuclear ambitions of Saudi Arabia and link them to regional geopolitics, e.g., the rivalry between Iran and Saudi Arabia. Finally, the economic reforms in Saudi Arabia, including the energy reforms, are often attributed to the rise of the Saudi Crown Prince Mohammed Bin Salman who is a part of a new reform-oriented generation of monarchs in the GCC [13]. There is clear evidence that Mohammed bin Salman has been the driving person behind the ongoing reforms. However, considering the reform pressures on the Kingdom, one could argue that these reforms would have been necessary regardless of who is in power.

### 3. Anatomy of the energy transition: sectors, instruments and targets

#### 3.1. The push for cleaner energies

In recent years, tangible progress can be observed regarding key energy transition indicators in Saudi Arabia (**Table 2**). Above all, the share of natural gas in power generation has increased significantly, now accounting for more than half of total generation. The additional gas came from the increased raw production of natural gas by the national oil company Saudi Aramco, which is expected to reach an annual production of around 238 billion cubic meters by 2030, although this increase would need to be supplemented by gas imports in the future (e.g. LNG) [14]. The increased gas production is an important factor for the decrease in the carbon-intensity of the Saudi economy. Other indicators have also improved, e.g., the decrease in residential electricity due to the subsidy reforms.

**Table 2.** Key energy transition indicators for Saudi Arabia.

Source: International Energy Agency for all indicators, except for renewables targets extracted from [15,16].

Energy transition indicator	2015	2018
Share of oil in power generation	63%	42%
Share of gas in power generation	37%	58%
Final energy carbon intensity (gCO <sub>2</sub> /MJ)	83.3	79.3
CO <sub>2</sub> emissions per unit of GDP (kg CO <sub>2</sub> /2015 USD)	0.8	0.7
Electricity consumption per capita (MWh/capita)	10.5	10.2
Electricity final consumption in the residential sector (ktoe)	12426	11215
Renewables target	9.5 GW by 2023	50% of power generation by 2030

With regard to the renewable energy generation, the share of renewable energy in the total electricity capacity was around 0.2% in 2018, with the total installed power generation capacity being ca. 76 GW in 2017 [17]. **Table 3** provides an overview of the renewables projects in Saudi Arabia. With the commercial operation of the Sakaka plant in 2021, the share of renewable energy is expected to increase slightly. However, the bulk of the projects is still under construction, with a significant development registered in 2021. In this year, Saudi Arabia has announced 7 new projects, with the tender of 600 MW Shuaibah project drawing the world record low price of \$0.0104/kWh [18]. It also declared a new and quite ambitious renewable energy target of 50% of power generation through renewables by 2030 [16].

**Table 3.** Current state of renewables projects in Saudi Arabia.

Source: Author's compilation.

Project	Technology	Size (MW)	Cost (million USD)	Status
Sakaka	Solar PV	300	320	Awarded in 2018, and opened in April 2021.
Dumat Al Jandal	Wind	400	500	Bids received (to be commercially operational in 2022).
Waad Al-Shamal	CSP	50	998 for the total capacity of 1390 MW	The project is a combined cycle power plant (using gas and 50 MW CSP component), and it was completed in 2018.
Sudair	Solar PV	1500	907	PPA signed in April 2021, and to commercially start in second half of 2022.
Shuaibah	Solar PV	600		
Rabigh	Solar PV	300		
Jeddah	Solar PV	300		
Qurayyat	Solar PV	200		
Al Madinah	Solar PV	50		
Rafha	Solar PV	20		
			Not available	Projects and PPAs announced in April 2021, while completion dates not available.

**Table 4.** Energy subsidy statistics for Saudi Arabia.

Source: International Energy Agency.

Subsidies per energy type in USD (2019) billion	2014	2019
Transport oil	35.6	14.4
Electricity	13.5	5.8
Gas	9.6	4.7
Other oil	9.9	3.8
Total subsidies as a % of GDP (MER)	9.5%	3.7%

### 3.2. Reforming subsidies and electricity tariffs

The subsidy reforms in Saudi Arabia have been significant in terms of both actual reductions and the resulting benefits for the state. Energy subsidy reforms have been implemented in all GCC states after the oil price drop in 2014 [19]. They covered fuel, electricity tariffs and water tariffs. Krane [20] reviewed these reforms in the GCC region and concluded that rising domestic demands, regional instability, low oil prices and international pressures enabled the enacting of these key reforms. The energy subsidy reforms in Saudi Arabia have led to significant fiscal savings and a much lower subsidization rate (see Table 4). Alongside environmental benefits such as lower carbon emissions through the decreased consumption (Table 3), the subsidy reforms constitute a key factor facilitating other aspects of the energy transition. First, the reforms will generate hundreds of billions of dollars of saved fiscal revenues in the upcoming years (Table 4 shows ca. 40\$ billion of saved spending in 2019 in comparison to the subsidization spending of 2014). These revenues can be reinvested in direct welfare benefits or in renewables' projects. Saudi Arabia has created the Saudi Citizens Account, which disperses direct benefit for eligible households as a compensation mechanism for the fiscal reforms such as the subsidy reforms or the introduction of the value added tax (VAT). In May 2021, the Ministry of Labor and Social Development, announced that the Citizen Account program already made 42 payments to around 10.4 million beneficiaries (ca. 40% of the population of Saudi nationals), with these payments totaling around 26\$ billion since the program's creation in late 2017. Second, the energy subsidy reforms are important for decreasing market distortions and allowing for the introduction of competition in the energy sectors. In this context, Aldubyan and Gasim [21] showed that the gasoline and residential electricity subsidy reforms have generated ca. 3\$ billion of welfare gains for Saudi Arabia and contributed to the decrease of consumption in 2018.

### 3.3. Built environment and low-carbon megaprojects

Energy certifications for buildings, district cooling systems and the construction of low-carbon megaprojects have been a popular instrument in the GCC region for ecological modernization and low-carbon development [15]. Saudi Arabia holds the bulk of new planned city developments in the GCC region such as the 500\$ billion Neom city project under construction. While many of the new planned cities incorporate energy efficiency aspects such as building certifications, only a few (mostly to be constructed) cities are incorporating a comprehensive low-carbon development approach [22]. In 2021, as a part of the Neom project, Saudi Arabia announced a futuristic city called "The Line", which should have no cars, an underground clean transport system and zero carbon emissions. The Line is supposed to extend for 170 kilometers, cost between 100 and 200\$ billion and to start construction already in 2021. For other new projects, Saudi Arabia has sought to extend the number of building certifications. Balabel and Alwetaishi [23] reviewed the status-quo of building certifications in Saudi Arabia, showing the existence of 159 projects with LEED certifications and the benefits of using the Saudi Mostadam building certification system (developed in 2019). Saudi Arabia is investing around 1.2\$ billion in green buildings, and it is retrofitting around 90 thousand mosques [24]. In fact, local energy certification systems have been developed in other GCC countries such as Qatar (the GSAS system), and the UAE (the Estidama system). While parts of the certification systems in Qatar and the UAE are mandatory, the Saudi system seems so far to be voluntary.

Another area of great importance for the energy transition is clean transport. In this regard, Saudi Arabia has recently increased its investments in public transport by establishing bus rapid transits (BRT) systems in major urban areas, light rail transit (LRT) between major cities, and a metro system in Riyadh (another metro system in Mecca is planned) [24]. Efforts to increase of the use electric vehicles are underway although only small pilot projects are being currently implemented such as importing some electric or hydrogen power buses and other utility vehicles.

### 3.4. Re-rethinking energy footprints and production in priority industries

The industrial sector is largest consumer of final energy in Saudi Arabia, and it has also witnessed significant increases in energy prices in order to improve energy use efficiency [25]. The bulk of the industrial basis in Saudi Arabia depends on energy-intensive sectors such as petrochemicals, steel, aluminum, cement and mining. Therefore, there have been several efforts to improve energy use in these sectors. For example, solar PV and natural gas are now used in the Waad Al Shamaal mining city. Furthermore, the petrochemical industry is being more engaged in the clean energy efforts. AlOtaibi et al. [6] report the involvement of this industry in the production of materials for renewable energies, e.g. the Wahaj factory in Hail city which can supply the needs of about 700 MW of solar panels. Besides, Saudi Arabia has promoted the use of clean hydrogen, and it aims to be a world leader in this sector. In 2021, a Memorandum of Understanding with Germany was signed to cooperate on clean hydrogen, particularly blue hydrogen which is based on natural gas and oil with carbon capture, utilization and storage [26]. Saudi Arabia has developed expertise in carbon capture, e.g. Aramco's Hawiyah plant that reinjects CO<sub>2</sub> into oil reservoirs for enhanced recovery, and thus sequesters 800 thousand tons of carbon dioxide per year (*ibid*).

Another key industry for the energy transition is desalination, which represents a key supply sector, and one of the largest electricity consumers in the GCC region (up to 12% of electricity in some GCC countries) [27]. The efforts to decrease the desalination energy footprint consist of constructing more energy-efficient plants (e.g. using reverse osmosis) and expanding solar desalination. Saudi Arabia has constructed a 15 MW solar PV desalination plant in Al Khafji, which is one of the largest solar desalination plants in the world. In the Neom project, water supply is supposed to come from solar desalination using CSP, including for the 1 million inhabitants of The Line city.

## 4. Discussion: assessing and contextualizing the saudi energy roadmap

The Saudi energy transition is taking shape, although its outcomes might take more years to materialize. In this section, some assessments can be provided on the level of engagement, nature and missing links of the Saudi energy transition. First, there is a clear evidence of a heightened engagement with energy efficiency and sustainable energy in the last years. The significant subsidy reductions and the accelerated construction of renewables projects are the clearest aspects of this transition. The transition is significant for Saudi Arabia and the region, and it is necessary considering the economic and sustainability pressures facing the Saudi Kingdom. The evidence of ongoing transition can be supported by results from global indices such as the Energy Transition Index published by the World Economic Forum (WEF). According to the 2021 report of this index which measures a range of issues related to the energy system performance and the enabling environment for the energy transition, Saudi Arabia is placed at the 81st place (out of 115 countries), in comparison to the 98th place in 2019 [28]. Second, the nature of this transition is top-down through renewables spending, public-private partnerships, megaprojects and regulatory reforms. Bottom-up approaches to sustainable energy development through the wide use of Feed-in-Tariffs (FITs), distributed energy systems, energy communities and decentralization are common in other countries (e.g. European Union), but they are absent in Saudi Arabia. The reasons for this delivery form of sustainable energy in the GCC region are largely political economic, e.g. maintaining state control, providing public jobs and maintaining the rentier state mentality (i.e. states ensuring political support through the provision of generous benefits to citizens via public jobs and some direct or indirect subsidization) [11,29]. Third, this paper has shown that the energy transition in Saudi Arabia is now deploying a range of instruments across several sectors. This is certainly a more comprehensive approach than the piecemeal (i.e. single interventions, pilot projects and inconsistent strategies) and even reluctant approach of the last decades. At the same time, there are still some missing links, which relate to encouraging sustainable and low-carbon lifestyles. The GCC region is known for the large per capita ecological footprints, and it is therefore important to encourage sustainable consumption and livelihoods. Currently, sustainable livelihoods are hindered by the inadequacy of environmental awareness and education as well as the segregated and often lavish urban planning [22]. Besides, there is a lack of investments in clean transport in order to facilitate the use of electric vehicles or to encourage walking and using bicycles in periods of moderate climate. In 2021, Saudi Arabia has announced the initiatives of Green Saudi Arabia and Green Middle East, which include a massive program to plant 50 billion trees and eliminate 130 million tons of carbon emissions. If realized, such initiatives can have positive spillovers with regard to life quality, awareness and sustainable living in the Kingdom and the wider region.

## 5. Conclusions

The emerging energy transition in Saudi Arabia is of great importance considering the Kingdom's high political and economic influence in the MENA region. It has been launched in 2016 through the Saudi National Vision 2030, but there are so far no systematic analyses of the progress, enablers and processes behind this transition. Economic pressures represent the main drivers of the Saudi energy transition. Besides, increased political will and engagement have facilitated the transition. This paper has highlighted key elements of the energy transition including the renewables development, the energy subsidy reforms, interventions in the built environment and interventions in energy-intensive industries. Key energy transition indicators show some success with regard to lowering carbon emissions and intensity as well as decreasing energy consumption, particularly in the residential sector. There have been new and ambitious renewables projects, including an impressive target of generating 50% of power from renewables by 2030. The energy subsidy reforms have been significant and delivered the needed spending for renewables development. They also allowed more competition and participation in the energy markets. Other aspects of the energy transition include low-carbon cities and enhancing energy efficiency in buildings through certifications. Besides, energy intensive sectors such as desalination or petrochemicals are being supported to incorporate and facilitate the use of clean energy. Overall, the Saudi energy transition has been significant, necessary and more comprehensive than past efforts. It should be complemented through encouraging sustainable livelihoods and low-carbon lifestyles.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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